A Study on the Suitability of Unmalted Sorghum as a Brewing Adjunct

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Grain samples of thirteen sorghum cultivars with diverse chemical composition were assessed for their suitability as brewing adjuncts based on proximate analysis. Sieving analysis of the grain as well as hot water extractables (HWE), hot water extractable protein (HWEP) and free amino nitrogen (FAN) were also determined. Cultivars with high starch and amylose contents together with low protein and fat percent are better suited as adjuncts depending on their hot water extracts and hot water extractable protein yields. Large variations in the uniformity of grain size were found, two of these cultivars (CSV-14R and M 35-1) had highest grain size. Cultivars CSH-5, CSV-11 and CSV-13 among the released cultivars were identified as better adjuncts which could be used along with barley malt for brewing lager beers.

Key Words: *Sorghum, brewing adjunct, brewing, hot water extract.*

INTRODUCTION

Sorghum grain is used for making traditional beverages in many countries of Africa and the use of sorghum for lager beer is known in Mexico and Nigeria[9,15]. Aisien and Muts[1] investigated the possibility of using sorghum malt in place of barley for beer production. In the brewery industry, unmalted cereals are used as adjuncts. Apart from malt, unmalted sorghum grain can also find uses as an adjunct in beer production. Adjuncts are essentially starchy materials with little or no protein content. The use of sorghum grits as adjuncts in lager beer brewing was reported by Hahn[2]. Earlier, Owuama and Okafor[10] reported the presence of amylase in the unmalted sorghum and suggested that this cereal was a favourable brewing adjunct[11]. Sorghum is not used as an adjunct in India mainly due to lack of awareness of its potential and lack of information on the suitability of Indian cultivars as brewing adjuncts. Hence, the present study proposes a systematic analysis of various improved sorghum cultivars to assess their suitability as beer brewing adjuncts.

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MATERIALS AND METHODS

Materials

The sorghum cultivars selected for this study included one local and 12 improved high yielding varieties and hybrids recommended for cultivation in India. All cultivars named as CSH are hybrids and those named as CSV and SPV are improved varieties. Grain samples were harvested during the 1992 crop seasons (rainy and post rainy seasons) from breeding trials conducted at the farm of NRCS, Rajendranagar, Hyderbad.

Methods

Physical analysis

250 g grain samples were used for sieving analysis. Sieves of different mesh sizes[6,7,10,12] were used to test the uniformity of grain size. 100 grains were counted manually and mass determined. The percentage recovery in a TADD mill (Tangential Abrasive Dehulling Device) (Venables Machine Works Ltd, Saskatoon, Canada) was also determined for all grain samples.

Chemical analysis

Grain samples were ground in a UDY Cyclone sample mill (UDY Corporation, Fort Collins, USA) to pass through a 0.4 mm mesh and the resultant flour used to determine the fat content by Soxhlet extraction[8]. The defatted flour of whole grain and dehulled grain was used for the determination of protein and α-amino nitrogen (AAN). Total nitrogen was determined using a Technicon auto analyzer[7] (Bran-Luebbe, Germany). Protein content was calculated by multiplying N% by a factor 6.25.

α-Amino nitrogen (AAN) was estimated by the ninhydrin method[5]. Fractionation of protein into fraction I was carried out using the extraction method of Landry and Moreaux[4] with minor modification. Sodium chloride solution (0.5 M) was used for the extraction of salt soluble protein. The grain sample was also extracted with water at 60°C for 1 h in a water bath, with the minor modifications of Morrall *et al*[9]. The extracts were used to determine water extractable protein and water extractables and expressed as hot water extractable protein (HWEP) and hot water extractables (HWE).

Determination of hot water extractables and hot water extractable protein

Hot water extractables (HWE) and hot water extractable protein (HWEP) were determined in whole grain, dehulled grain and grits. The hot water extract (10 ml) was pipetted into a Technicon digestion tube and evaporated to dryness. The residue was digested with sulphuric acid and the protein content determined by the Technicon auto analyzer method[7]. Hot water extractable protein was expressed as g/100g total protein. The hot water extract (10 ml) was pipetted into a pre-weighed aluminium dish and evaporated overnight at 110°C. The aluminium dish was cooled is a desiccator and weighed. The proportion of hot water extractables were calculated and expressed as g/100g flour.

RESULTS AND DISCUSSION

Grains of seven hybrids and six varieties of sorghum were evaluated for five proximate principles, i.e. starch, amylose, fat, protein and fibre and the data are presented in Table I. Much variation was observed among the cultivars for starch, protein, fat and fibre. Starch content ranged from 63.4% in CSH-6 to 72.5% in CSV 14R. The variation in starch content was statistically significant. Among the thirteen cultivars, six cultivars (CSH-5, CSH-9, CSH-13, CSV-11, CSV-13 and CSV-14R) had high starch content above 70%. The amylose content of sorghum cultivars varied from 17.8% to 21.9%. All the high starch

TABLE I. Proximate chemical composition and millability of grain in selected sorghum cultivars

Cultivar	Starch %	Amylose %	Protein %	Fat %	Fibre %	Recovery in TADD mill %
CSH 1	69.7	21.9	9.98	3.08	1.65	70.9
CSH 5	70.8	20.9	10.93	2.99	1.86	83.9
CSH 6	63.4	17.8	10.03	3.07	1.78	78.9
CSH 9	71.2	19.2	7.95	2.86	1.79	77.4
CSH 11	67.8	20.4	10.0	3.07	2.10	67.8
CSH 13	67.7	18.1	10.7	2.93	1.90	86.4
CSH 14	71.2	21.9	9.6	2.90	1.70	90.2
CSV 10	67.9	20.3	11.2	2.40	2.30	89.3
CSV 11	70.5	18.4	9.4	2.50	1.99	81.1
SPV 462	66.2	21.2	8.9	2.30	2.40	78.2
CSV 13	71.8	19.3	9.45	2.57	2.14	80.8
CSV 14 R	72.5	19.5	11.5	2.70	1.67	90.0
M 35-1	68.1	18.9	9.24	2.58	1.57	87.3
C.D at 5 %	3.2	2.36	0.38	0.44	0.34	1.69

Values are means of two independent analyses from defatted flour expressed at 10 % moisture level.

cultivars, except CSV-11 used by this study also had high amylose contents. Protein content ranged from 7.95% (CSH-9) to 11.5% (CSV-14R). Fat content varied from 2.3% (SPV 462) to 3.08% (CSH-1). Cultivars having high starch and amylose contents with a low protein and fat percent are better suited as adjuncts depending on their hot water extracts and hot water extractable protein yields. Crude fibre among the thirteen cultivars varied from 1.57% (M 35-1) to 2.4% (SPV 462). The recovery of dehulled grain in the Tangential Abrasive Dehulling Device (TADD) varied significantly among the cultivars (Table I) but grain recovery was not related to any of the principal chemical constituents.

not always associated with higher starch content.

The hot water soluble extracts or hot water extractables (HWE) and percent hot water extractable protein (HWEP) of whole, dehulled and grits in different cultivars of sorghum are presented in Table III. The HWE were higher when the samples were in flour form. Little variation in HWE was observed when the samples were whole or dehulled grain. Grits have a lower HWE in all the cultivars studied. In general, HWE were slightly higher in dehulled flour compared with the HWE from whole flour in all the sorghum cultivars, except SPV-475. The percent HWE in whole flour ranged from 5.1 (CSV-10) to

TABLE II. Size and uniformity of the grain in different cultivars of sorghum

	Percent Fraction Retained By the Sieves of mesh size				100 Grain wt. of fraction retained at different meshes		
Cultivar	**10/64**	**8/64**	**7/64**	**Remainder**	**10/64**	**8/64**	**7/64**
CSH -1	60.35	38.7	0.78	0.12	3.11	2.50	1.43
CSH --5	12.99	84.1	2.56	0.23	3.16	2.43	1.33
CSH - 6	4.33	91.3	3.92	0.31	2.69	2.35	1.46
CSH -9	13.60	82.1	4.01	0.18	3.47	2.38	1.41
CSH -11	11.70	86.3	1.78	0.10	2.99	2.13	1.51
CSH - 13	27.3	71.7	0.76	0.15	3.61	2.68	1.59
CSH -14	26.6	72.4	0.87	0.05	3.25	2.61	1.36
CSV -10	53.86	45.8	0.29	0.09	3.48	2.35	1.36
CSV -11	1.75	84.0	13.2	0.80	2.78	2.08	1.39
SPV -462	14.93	75.99	8.38	0.40	3.18	2.02	1.34
CSV -13	30.44	68.74	0.73	0.08	3.00	2.33	1.29
CSV -14R	70.35	29.0	0.51	0.07	3.75	2.56	1.06
M 35 -1	64.03	35.51	0.42	0.12	3.40	2.70	1.40
C.D at 5 %	3.59	3.64	1.06	0.11	0.21	0.83	0.16

Values are mean of two independent analyses expressed at 10 % moisture level

The sieving analysis of the grain samples of the cultivars of sorghum is presented in Table II. High variation in the uniformity of grain size was found among these cultivars. Two of these cultivars (CSV-14R and M 35-1) had highest grain size. Between these two, CSV-14R had the bolder grain with higher uniformity and highest starch content. These cultivars were grown during post rainy (September-December) season. Among the rainy season (June-October) cultivars CSH-1 and CSH-10 had a bigger grain size while CSH-5, CSH-6, CSH-9, CSH-11 and CSV-11 had better grain size uniformity. Higher grain weight was

9.8 (SPV-475) whereas in the dehulled flour, it ranged from 6.4 (M 35-1) to 9.02 (CSH-1). Jayatissa *et al*[12] also reported that the HWE values varied considerably among sorghum cultivars. No significant variation for HWE from the grits of all cultivars was observed.

The percent HWEP in dehulled flour was much higher compared with that from whole flour, except in CSH-5 and SPV 462. The percent HWEP in whole flour showed widest variation, from 5.1 (CSV-14R) to 15.2 (SPV-462). This variation in dehulled flour ranged from 6.8 (CSH-5)

TABLE III. Percent hot water soluble extracts and hot water soluble protein at 60°C in different cultivars of sorghum

	Hot water soluble extracts			Hot water soluble protein		
Cultivar	Whole flour	Dehulled flour	Grits	Whole flour	Dehulled flour	Grits
CSH-1	6. 9	9.02	3.7	6.7	10.4	6.01
CSH-5	7. 1	7.04	3.91	12.1	6.8	6.11
CSH-6	6.7	8.4	3.72	12.2	10.22	5.38
CSH-9	8.0	8.4	3.46	11.9	12.5	8.29
CSH-11	6. 9	8.4	3.37	9.7	11.23	5.9
CSH-13	5. 6	7.5	3.29	9.5	11.89	6.6
CSH-14	6. 0	7.7	3.04	8.9	10.84	4.7
CSV-10	5.1	6.7	3.67	11.9	12.64	5.5
CSV-11	7.1	8.3	3.51	14.7	11.81	5.6
SPV-462	8.6	8.9	3.37	15.2	11.95	5.6
CSV-13	9.8	7.2	3.85	12.0	12.9	7.4
CSV-14R	5.7	7.7	3.09	5.1	9.5	6.9
M 35-1	6.5	6.4	3.18	5.9	10.9	9.2
C.D at 5%	0.89	0.61	0.67	6.66	0.69	0.51

Values are Mean of two independent analyses expressed at 10 % moisture level.

to 12.9 (SPV-475). Again grits showed lower percent of HWEP in all the cultivars. Five of the six cultivars which were analysed for high starch content also showed high percent of hot water extracts. Another variety, SPV-462 which contained 66.2% starch also had HWE and HWEP. Subramanian *et al*[13] observed that the diastatic activity in sorghum correlated positively and significantly with water extractables ($r = 0.87$, $p < 0.01$). This indicated that cultivars with HWE and high HWEP may also have advantages as adjunct.

Fraction I protein analyzed in different cultivars of sorghum is presented in Figure 1. The salt soluble protein (fraction I) in cultivars used in the present study varied significantly from 10.7 (M 35-1) to 18.4 (CSV-14R) (Fig. 1). Cultivars with high starch content again contained high percents of fraction I protein ($r = 82$, $p < 0.05$), suggesting that cultivars with high fraction I protein had high diastatic activity. This study thus indicated that cultivars having higher HWE, high HWEP and fraction I protein could be better adjuncts for beer brewing.

The effect of dehulling on AAN content, protein and fat is given in Table IV. The dehulling process decreased the AAN content. The AAN content in whole flour varied almost three fold from 64.0 mg/100 g to 185 mg/100 g. Dehulling significantly reduced the AAN variation from 62.0 mg/100 g to 101.5 mg/100 g. Sorghum malt is notable for high concentrations of free AAN compared with barley malt which is reported to contribute to the quality of the beer[3]. According to Taylor and Boyd[14] HWE and free AAN are important for the quality of the beer and sorghum malt has a superior FAN composition and nutritional quality than barley malt. The high starch cultivars CSH-5, CSV-11 and CSV-13 had higher concentrations of free AAN.

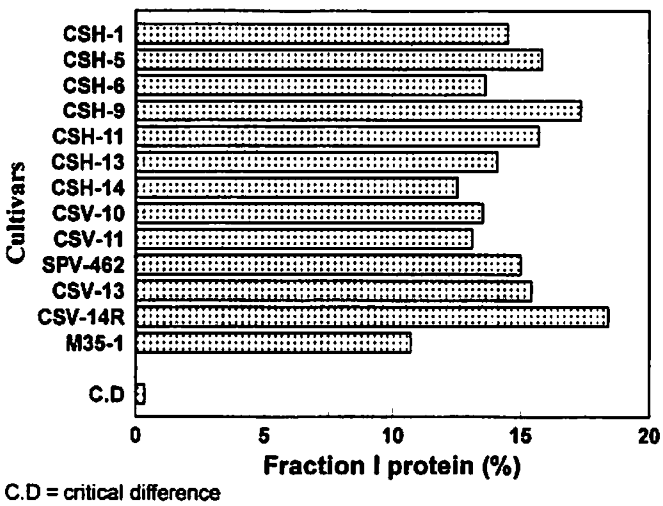

FIG. 1. Profile of Fraction I protein content in different cultivars of sorghum.

In conclusion, among the 13 cultivars examined by this study, CSH-5, CSV-11 and CSV-13 were identified as

TABLE IV. Protein, a-amino nitrogen and fat composition of whole and dehulled grain

Cultivar	Whole Grain α-amino nitrogen (mg/100g)	Whole Grain Protein (%)	Whole Grain Fat (%)	Dehulled Grain α-amino nitrogen (mg/100g)	Dehulled Grain Protein (%)	Dehulled Grain Fat (%)
CSH-1	75.0	9.98	3.08	69.5	10.35	2.27
CSH-5	134.5	10.93	2.99	62.0	10.68	2.10
CSH-6	85.0	10.03	3.07	73.5	9.28	2.45
CSH-9	85.0	7.95	2.86	67.5	7.65	2.02
CSH-11	103.0	10.04	3.07	94.5	10.11	2.05
CSH-13	64.0	9.55	2.99	72.0	9.96	1.87
CSH-14	79.5	10.65	2.89	63.0	8.01	2.06
CSV-10	98.0	11.16	2.48	98.5	11.31	1.81
CSV-11	106.0	9.41	2.48	92.5	9.86	1.76
SPV-462	126.5	8.91	2.27	93.0	9.46	2.05
CSV-13	185.5	9.45	2.57	101.5	9.07	1.52
CSV-14R	76.0	11.5	2.70	62.0	8.54	1.52
M 35-1	82.5	9.5	2.58	80.5	8.25	2.15
C.D at 5%	2.57	0.38	0.44	2.57	0.47	0.39

Values are mean of two independent analyses expressed at 10 % moisture level

the most suitable for use as adjuncts alongside barley malt for brewing lager beer.

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